

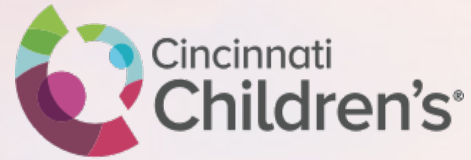


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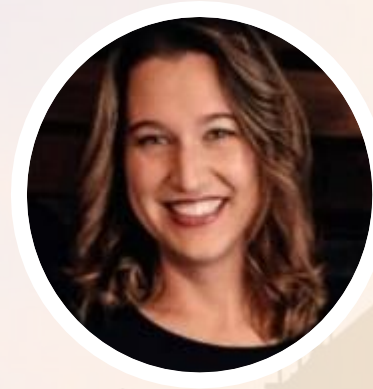
Integrating Human Factors in Evidence-Based Healthcare Design: An Expert Panel Discussion

C06 | Thursday Sept. 25, 2025 | 1:00PM-2:00PM

San Diego Convention Center | San Diego, California



Researcher:
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EBD Expert:
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FACHA, EDAC**
Principal and Sr. Medical
Planner, GBBN Architects

Learning Objectives



1. Identify common principles, work process and methods/tools, employed by Human Factors and Ergonomics (HFE) engineers and Evidence-Based Design (EBD) architects in healthcare facilities.
2. Learn from various case studies that use different types of mockups and emerging technologies to enhance user outcomes and streamline project delivery.
3. Develop a shared understanding of key challenges and opportunities for collaboration between HFE engineers and EBD professionals in different phases of healthcare design projects.
4. There are 50+ HFE engineers that work in healthcare systems, and this panel will advocate for close collaborations between them and healthcare design professionals at different scales.

Agenda



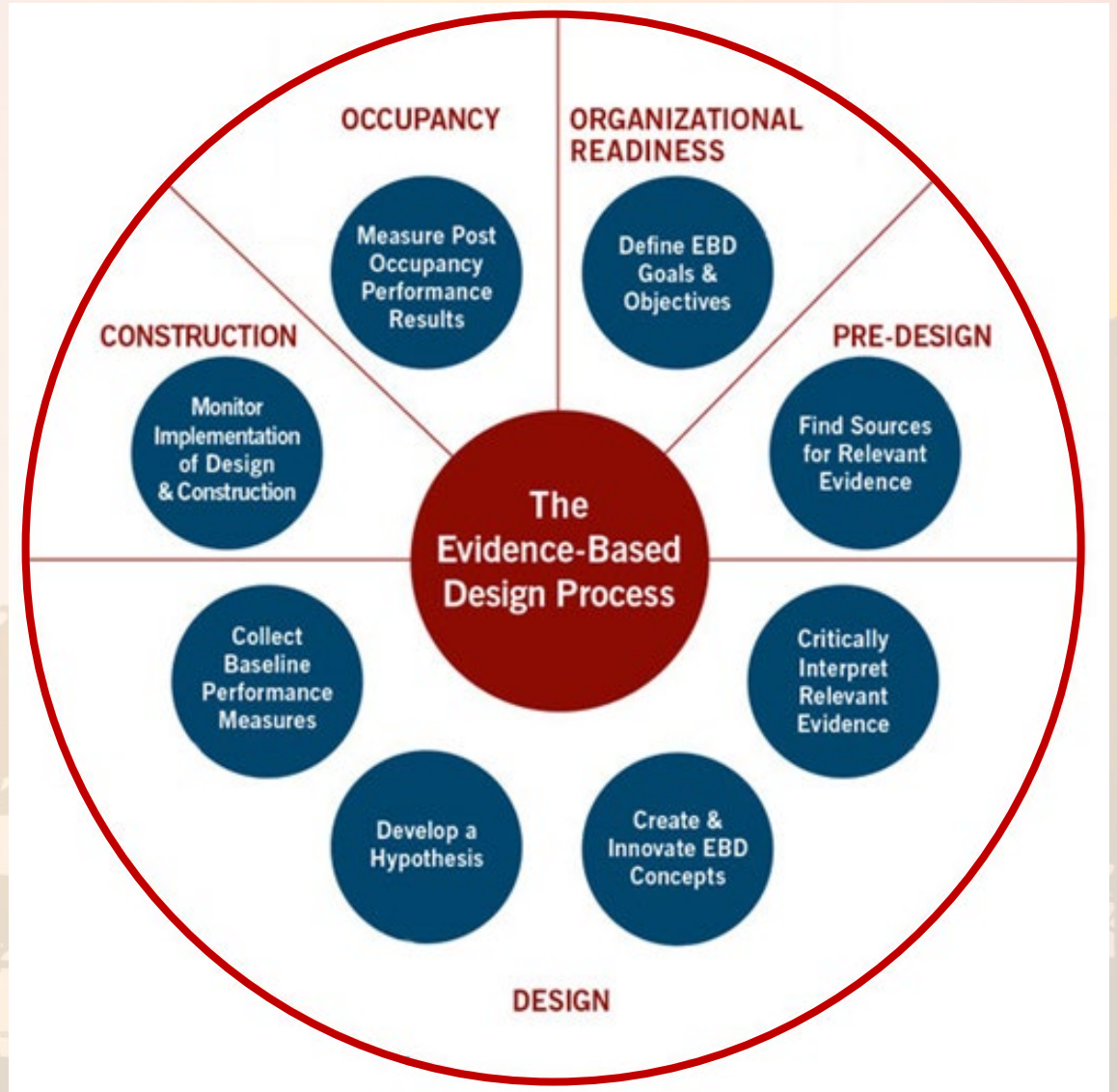
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1. Research Context Overview
2. Questions for expert panelists, and experience sharing
3. Introducing an EBD-HFE integrated framework
4. Case studies
5. Q&A and audiences discussion

Research Context

Evidence-Based Design (EBD)

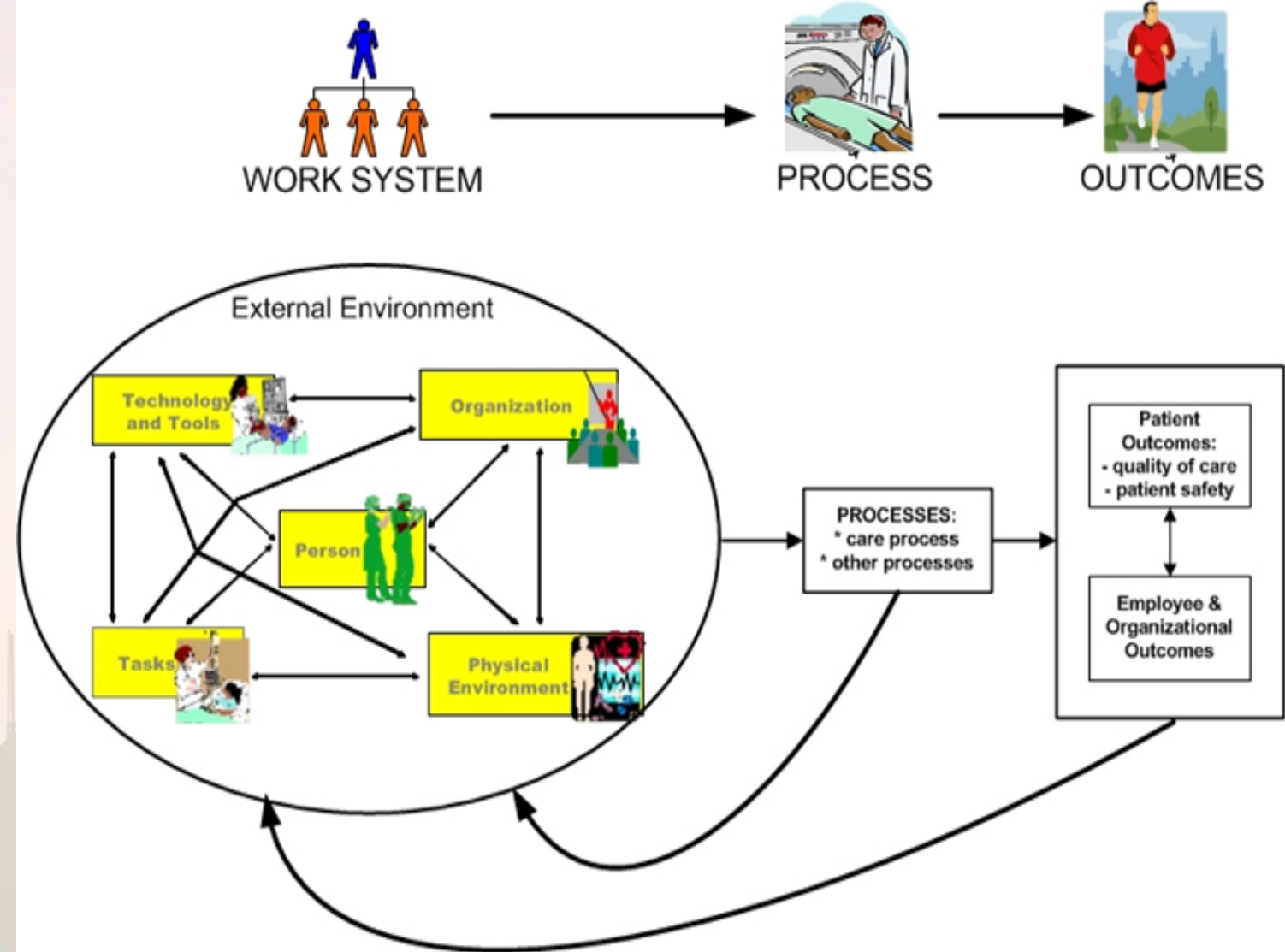
is the process of basing decision about the built environment on credible research to achieve the best possible outcomes (The Center for Health Design).



The EBD process in healthcare design, adapted from The Center for Health Design.

Research Context

Human Factors and Ergonomics (HFE) concerns the individual, organizational, and environmental aspects that influence human performance, health, and well-being, with particular emphasis on risk management, patient safety, and staff performance.



The Systems Engineering Initiative for Patient Safety (SEIPS) Model (Carayon et al., 2006)

Questions for the Experts



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- **How can Evidence-Based Design (EBD) and Human Factors and Ergonomics (HFE) be applied in healthcare system design and delivery?**

Questions for the Experts



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- **What factors does HFE take into account that EBD does not?**

Questions for the Experts



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- **What kind of user behaviors are most impacted by the application of HFE?**

Questions for the Experts



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- **What are the best strategies for engaging HFE experts in healthcare design projects, and at what stage should collaboration occur?**

Questions for the Experts



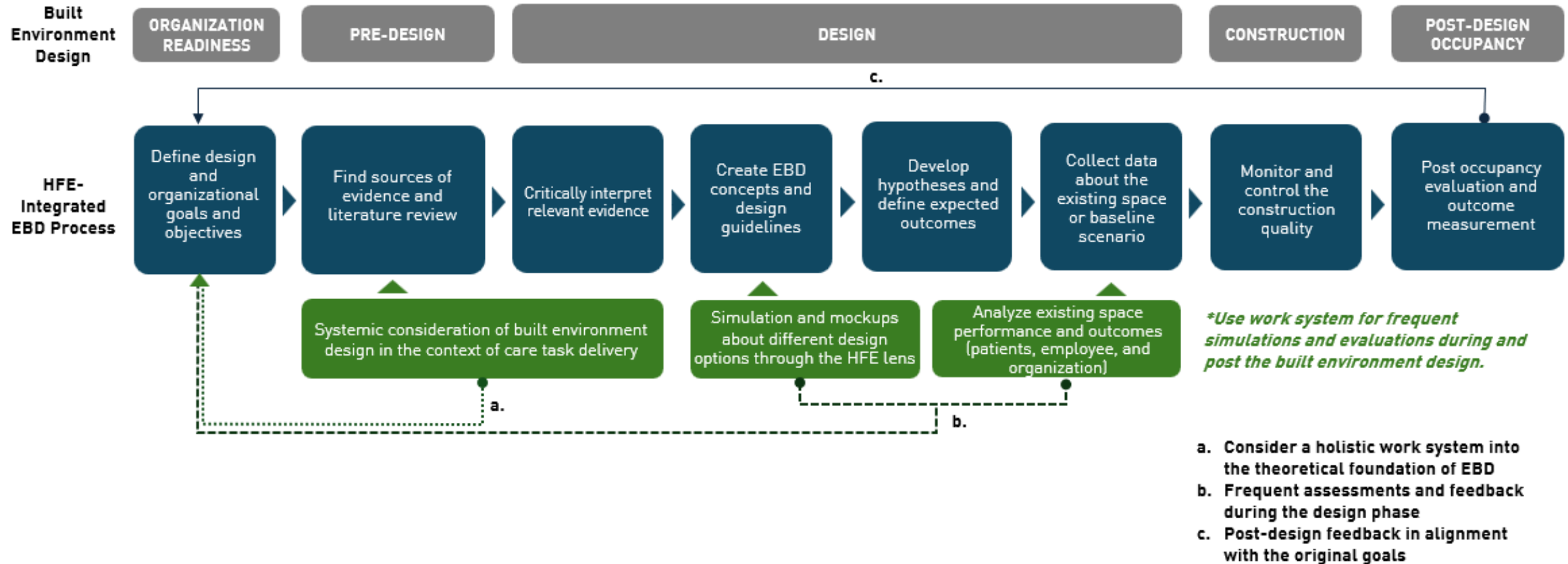
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- **How can applying HFE and EBD influence return on investment (ROI) in health system design and delivery?**

An Integrated Framework

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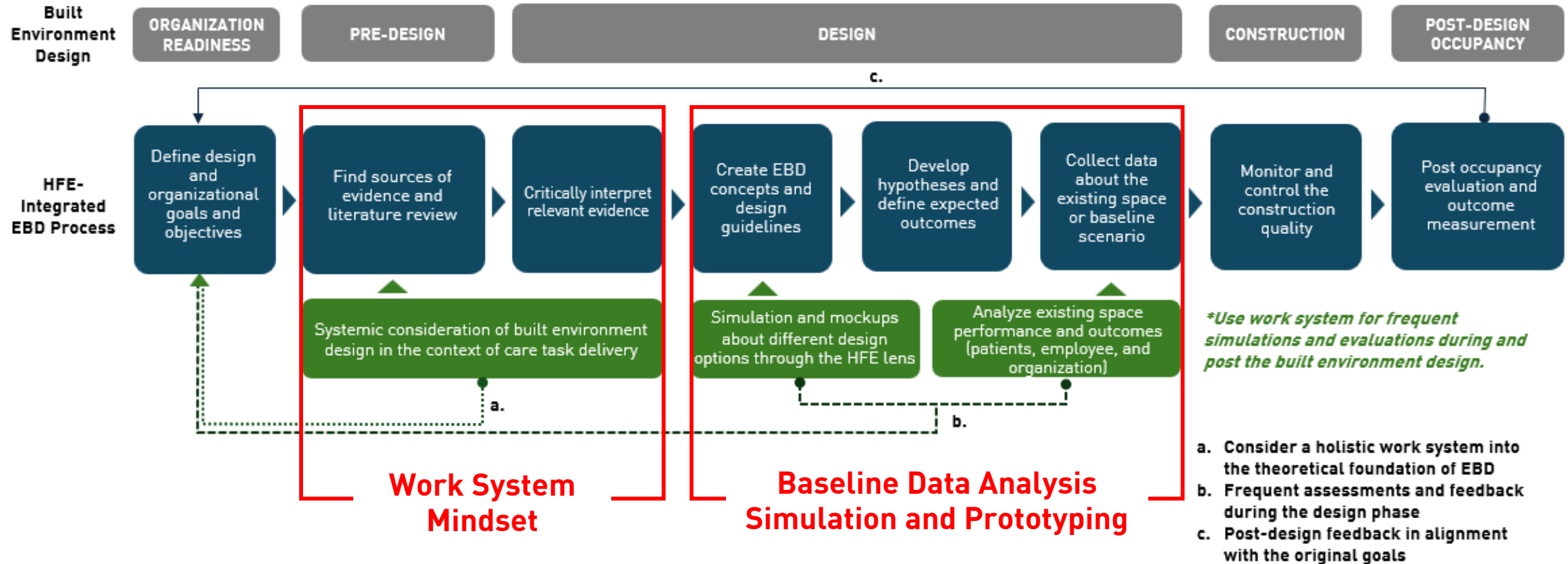
HFE-EBD + HFE HFE-Integrated EBD Process in a Healthcare Built Environment Project



An Integrated Framework

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HFE-Integrated EBD Process in a Healthcare Built Environment Project



Simulation and Prototyping

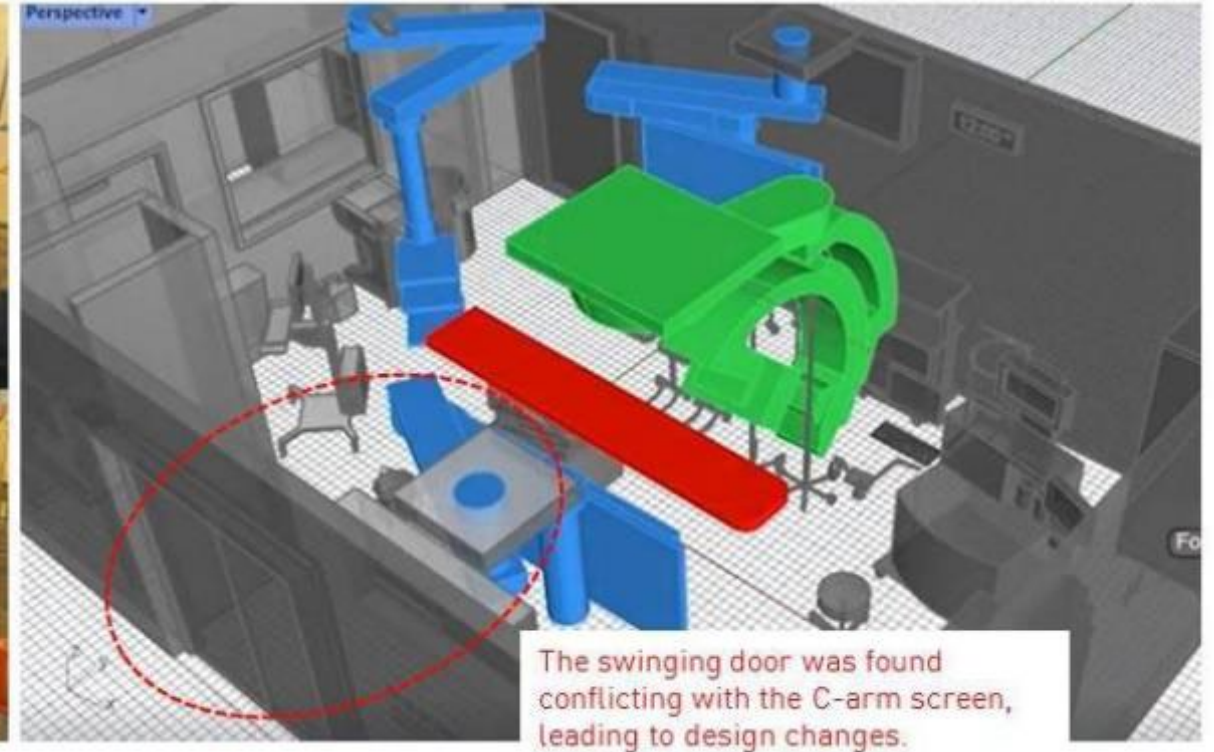
Frequent Assessment Example: OR Simulation

Testing/ Prototyping

Hybrid simulation with physical mockups and augmented reality (AR).

HF review focused on locations for equipment, furniture, and supplies to support tasks and links for different staff roles.

Architects used EBD in real time to refine the design and allow stakeholders to participate in the full process.



Images Courtesy of GBBN Architects

Simulation and Prototyping

Carilion Clinic Trauma Room Mock-Up



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A. Case Study 1 Trauma bay mock-up using cardboards



B. Original Layout



C. Updated Layout

Bump Analysis

- Equipment
- Pharmacist
- RN #1
- RN #2
- ACP #1
- ACP #2

Images Courtesy of Carilion Clinic

Simulation and Prototyping

Carilion Clinic Trauma Room Mock-Up



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A. Case Study 1 Trauma bay mock-up using cardboards



B. Original Layout



C. Updated Layout

- The mock-up findings led to the decision to eliminate one cabinet per bay from trauma bays; each cabinet costs \$16,000.
- $\$16,000 \times 4 = \$64,000$ direct cost avoidance



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CASE STUDIES

EMERGENCY DEPARTMENT UPFRONT AREA

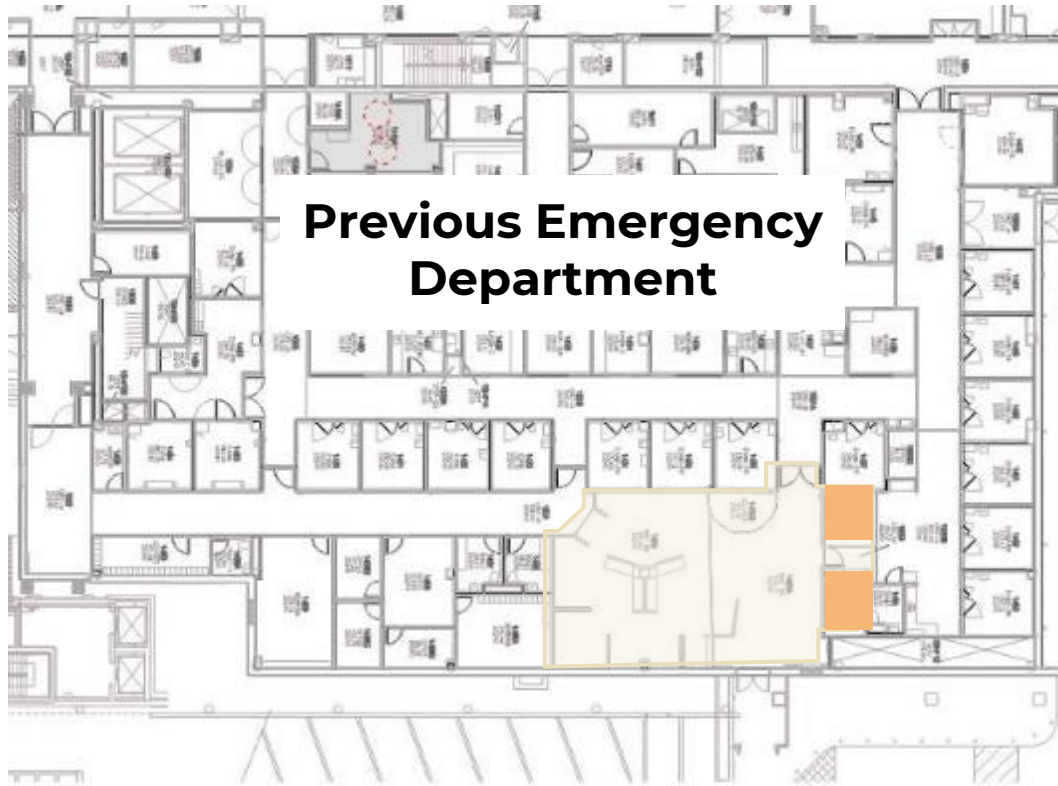


Methods	Literature review, case studies, simulation, volume data review
Goals	Transform the “front door”, empower staff with resources, Inspired by children, beyond the expected
Hypothesis	Implement the Fast Track process, Design for positive distract, Update the arrival experience
Testing/prototyping	Annotations on design, augmented reality simulations of design options
Solutions	Final design
Post-Occupancy Evaluation	Test the hypothesis



		2021	2022	2023
Volume		35,680	46,592	42,666
ALOS (minutes)		248	264	325
AMA		21	31	31
LWBS		2363/7%	4173/9%	2924/7%
Admit		4,681/13%	7768/17%	7024/16%
EDIP/Boarders		1,111	1332	802
Psych Patients		841	896	766
Acuity	ESI 1	301/1%	339/1%	329/1%
	ESI 2	6,764/19%	7879/17%	7729/18%
	ESI 3	16,193/45%	18,193/39%	16,429/39%
	ESI 4	14,641/41%	18,862/40%	16,540/39%
	ESI 5	1,165/3%	1069/2%	924/2%
	Not Listed	189	229	155

Hypothesis



Simulation and Prototyping



Simulation and Prototyping included reviewing augmented reality of the department options early in design. Prototyping occurred again later in design with physical mock-ups tied with the AR.

Fast Track Room

Use EBD to influence detail solutions

- Electronic bedside charting reduces medical errors
- Accessible controls for patient
- No cubicle curtain – reduces hospital acquired infections
- Easily accessible hand washing sink near patient room door
- Culturally relevant artwork helps calm patients and relieve stress



Design Solutions

ISSUE	HISTORY	SOLUTION
Overcrowding entry	Minimal space for pivot nurse	• New entry sequence with pivot nurse and triage process
Limited waiting space	Overcrowded waiting especially during peak season	• Additional space with new process to decrease wait times
Long wait times	Old process dictated wait times	• New process started with Fast Track rooms • Additional positive distraction elements including lighting, art, and icons
Need to blend space in with new system branding	n/a	• Incorporate the health system brand into the patient spaces
Security	Security was the first person and often mistaken for triage	• New security location



POST ANESTHESIA RECOVERY UNIT

Methods	Simulation, volume data review, mock-ups, observation
Goals	• Increase operational efficiency • Promote and optimize care • Right size number of bays required • Decrease traffic through the dept
Hypothesis	• Consolidating ORs will eliminate PACU cut through traffic • Improving waiting room access and creating Kissing point reduces traffic • “Neighborhoods” of open bays will improve experience and acoustics
Testing/ prototyping	• Discrete event simulation and scenario testing, High Fidelity Mockups during design
Solutions	• Design iterations led to relocation of team desk, elimination of circulation ring
Post-Occupancy Evaluation	• Gemba walk – phased construction goes through 2028



Discrete Event Simulation

- Actual case data from Epic OpTime used to model cases according to a block OR schedule and tracking patient through prep, procedure and recovery
- **Determined that fewer bays required than code mandated and got a waiver.**

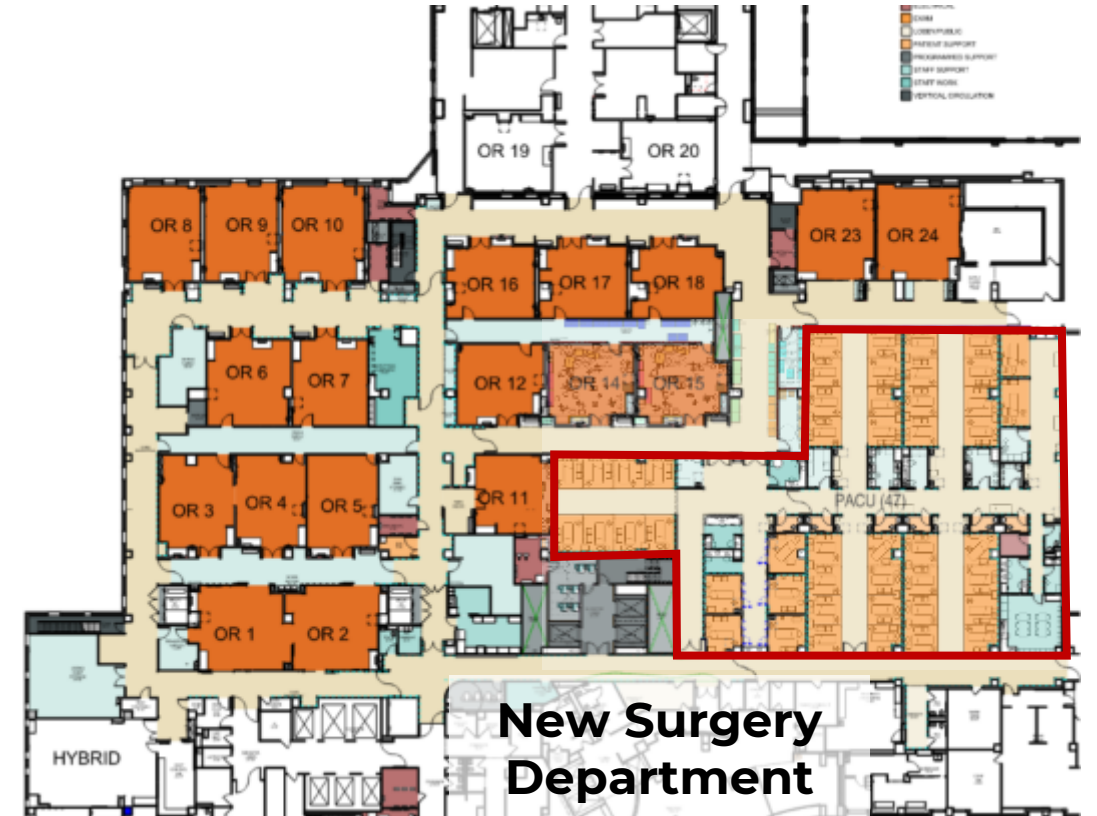
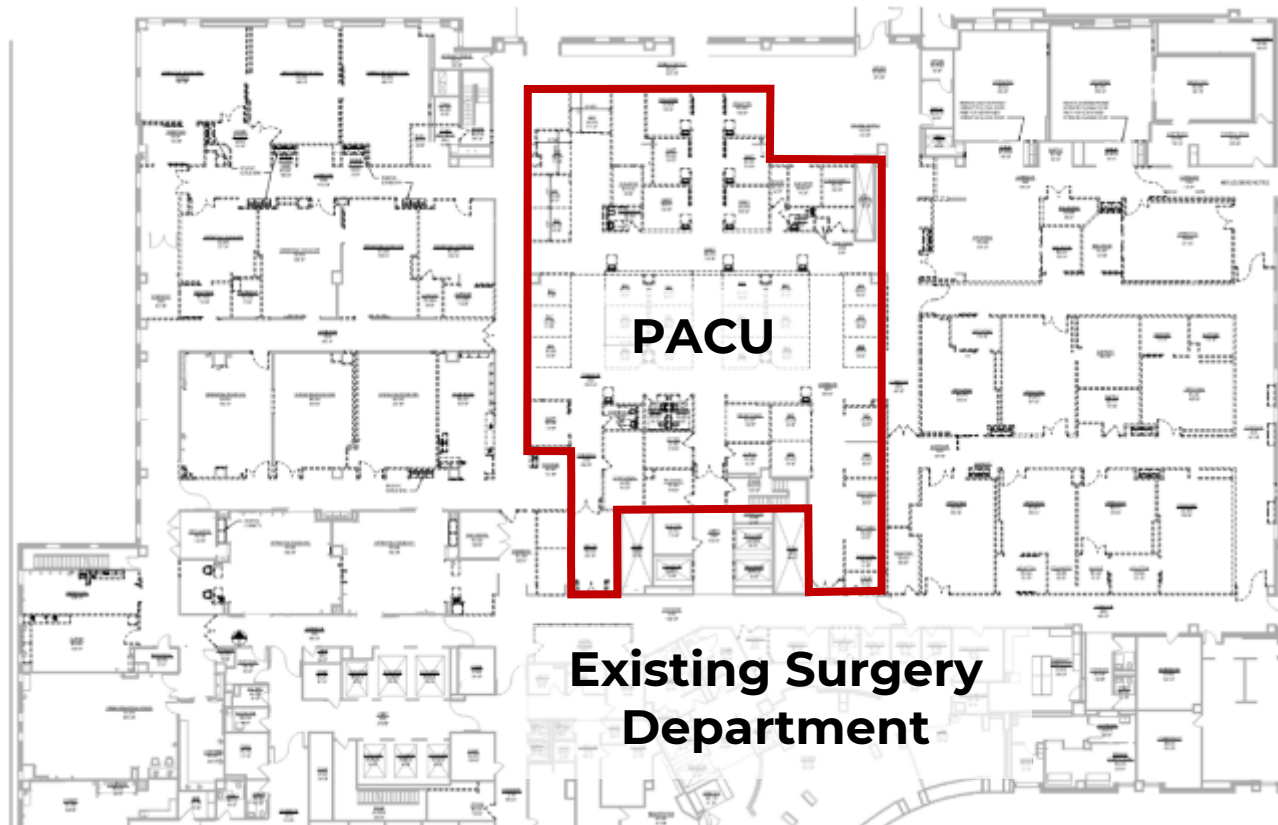


Discrete Event Simulation

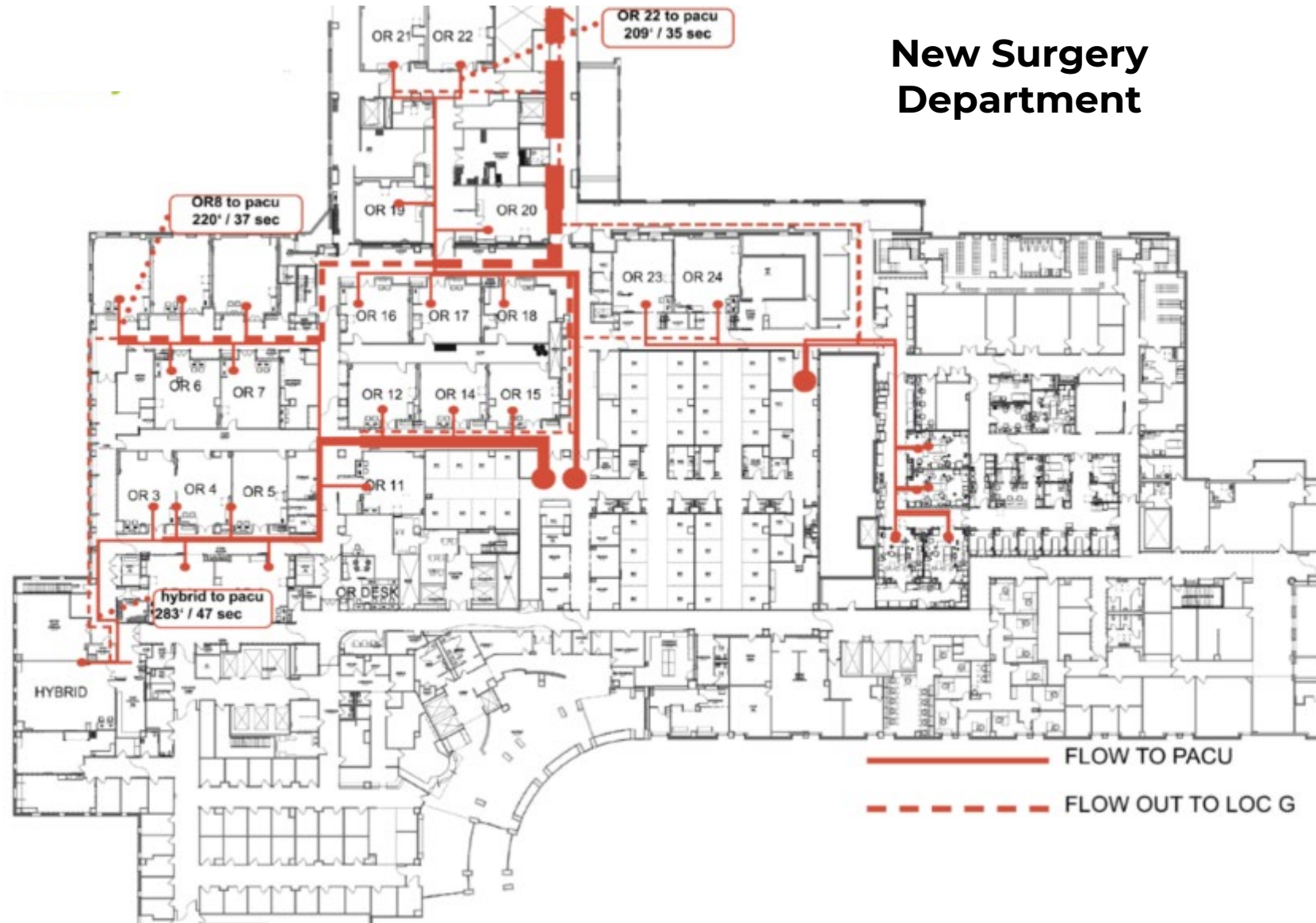
- Baseline and two alternate scenarios tested:
 - Scenario 1 (Busy Day): emulates a high-volume day
 - Scenario 2 (Typical Day): emulates a typical day
 - Baseline (Existing): observed values from 2018

METRIC / KPI	Existing Conditions		Scenario 1 (Unsmoothed)		Scenario 2 (Smoothed)	
	Main	Proc	Main	Proc	Main	Proc
Average Daily Cases	90 cases	-	110 cases	27 cases	94 cases	27 cases
Average Recovery Duration	78 minutes	-	80 minutes	67 minutes	80 minutes	67 minutes
Average PACU Population*	15 patients		24 patients		21 patients	
Peak PACU Population*	25 patients		33 patients		31 patients	

Before/After Review



Travel and Flow Studies



Travel and Flow Studies

New Surgery Department

Same Day Family / Patient Arrival

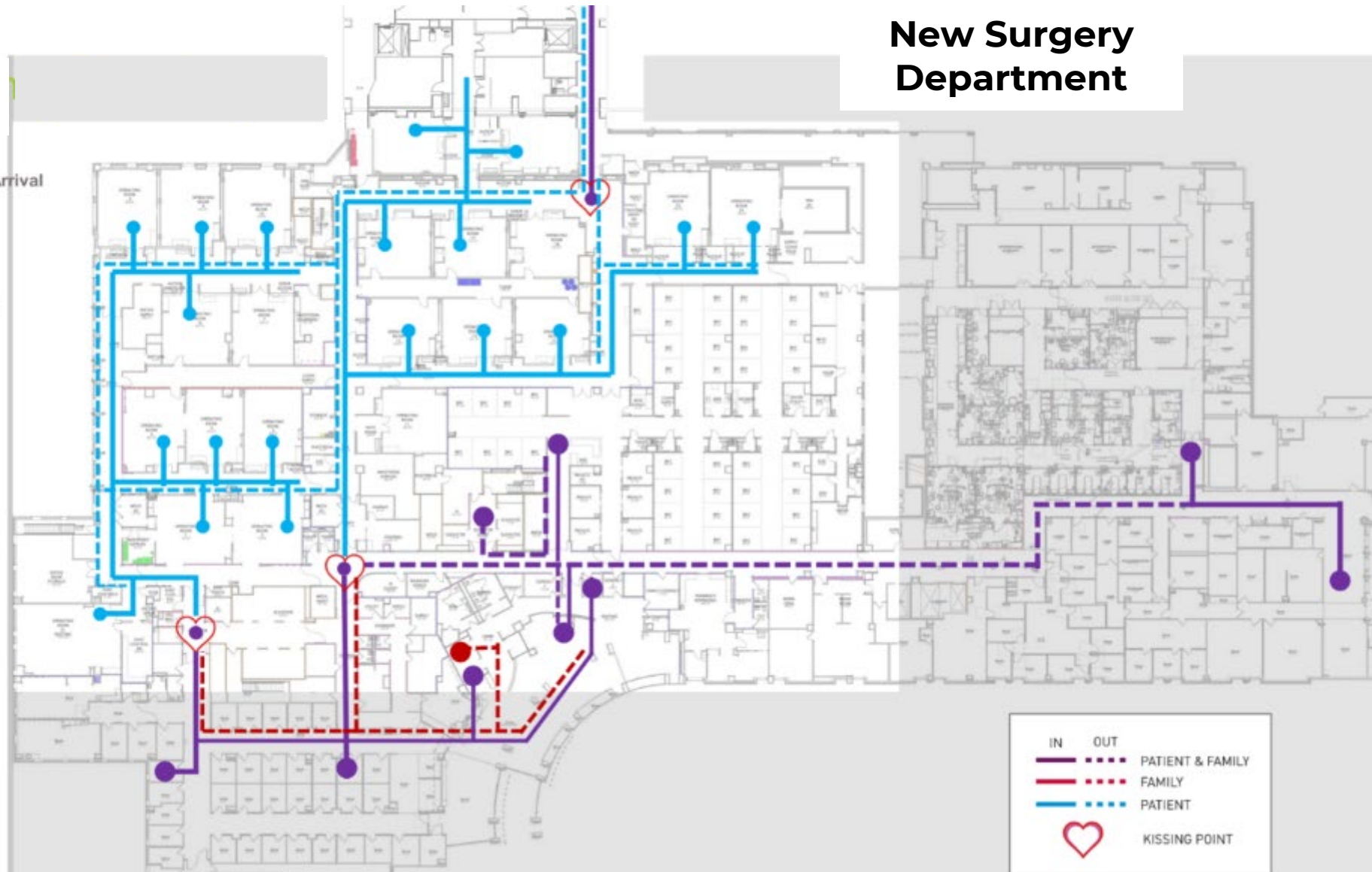
- Badging at B1
- Register at B3
- Patient to prep
- Patient/Family to Kiss Point
- Patient to OR
- Family to Waiting

Inpatient Family/Patient

- Family to Consult
- Inpatient to patient room
- Family Exit to Waiting
Elevators to B1 then
A-G inpatient room

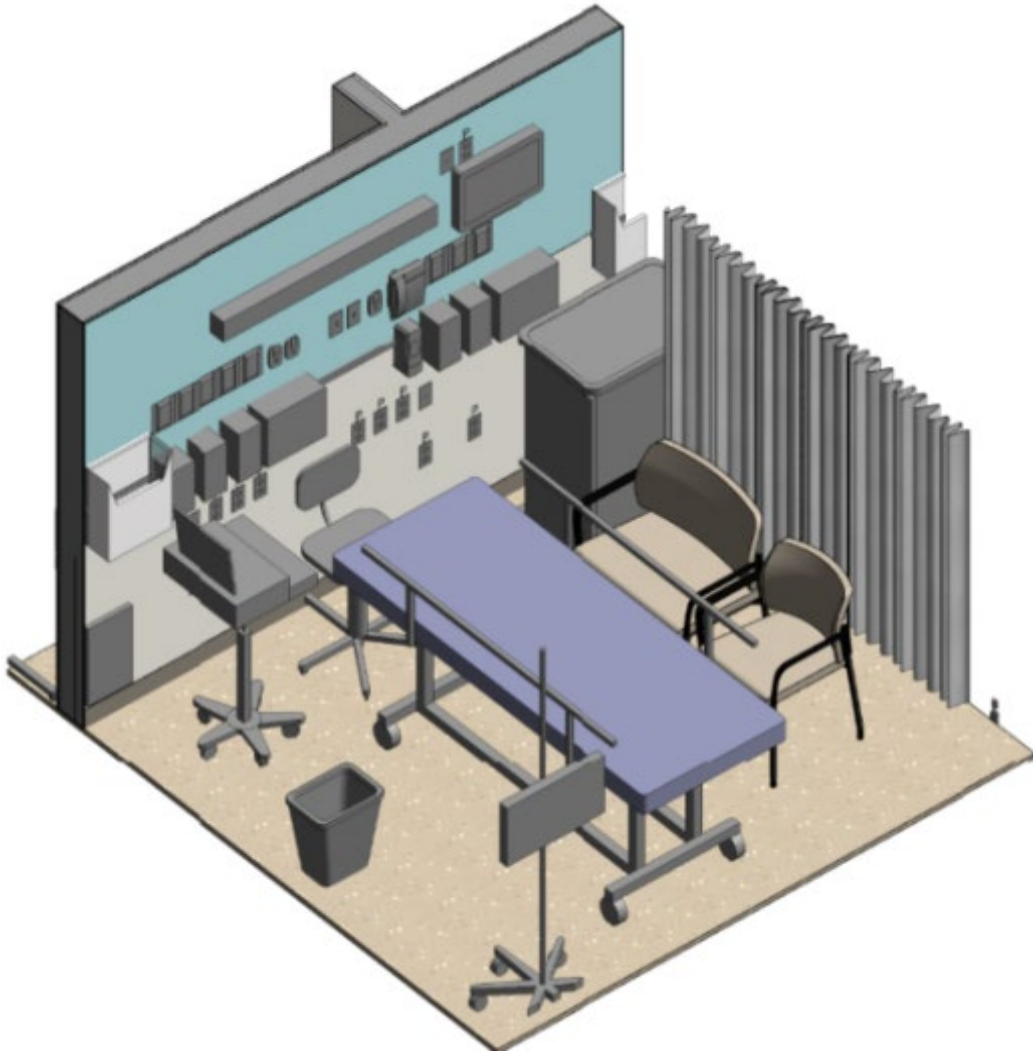
Outpatient Family/Patient

- Family to Consult
- Outpatient to PACU
- Family to PACU
- Patient/Family Exit
(3 Bank Elevators)
- Patient/Family Exit B1



Courtesy of GBBN Architects

Testing and Mock-ups

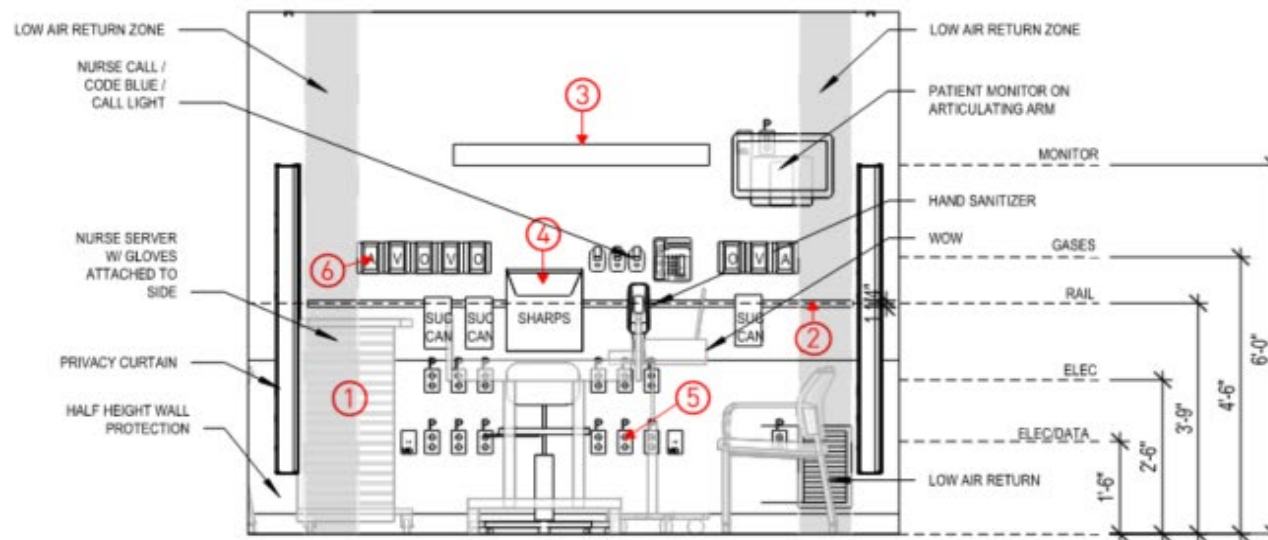


- A mockup was built to test the headwall configuration. Comments/changes from Day 1 were then reviewed in Day 2.
- Acoustic concerns prompted the design team to propose a full height curtain. Ultimately, the client decided to use curtains that had mesh tops and did not extend to the floor.

Courtesy of GBBN Architects

2-Day Mock-ups

PACU Headwall Mock Up Day 1 July 21, 2020



2

OPEN BAY HEAD WALL

DS3

SCALE: 3/8" = 1'-0"



KEY DECISIONS

1. Nurse servers will be shared - 1 between 2 bays

2. The equipment rail received positive feedback - basis of design is the Nexxspan rail

3. The wall mounted light will be on a dimmer and will provide both direct and indirect lighting

4. Move the sharps container to the left of the headwall

5. Reduced the number of duplex electrical outlets - 4 per side of the stretcher (total of 8 below the rail). There will be a duplex for parent use (include USB + regular outlet). There will also be an outlet for the physiologic monitor.

6. Moved gases up 2" to make room for the suction canisters to mount below.

LOW AIR RETURN ZONE

NURSE CALL
CODE BLUE
CALL LIGHT

NURSE STATION
W/ GLASS
ATTACHED

PRIVACY CURTAIN

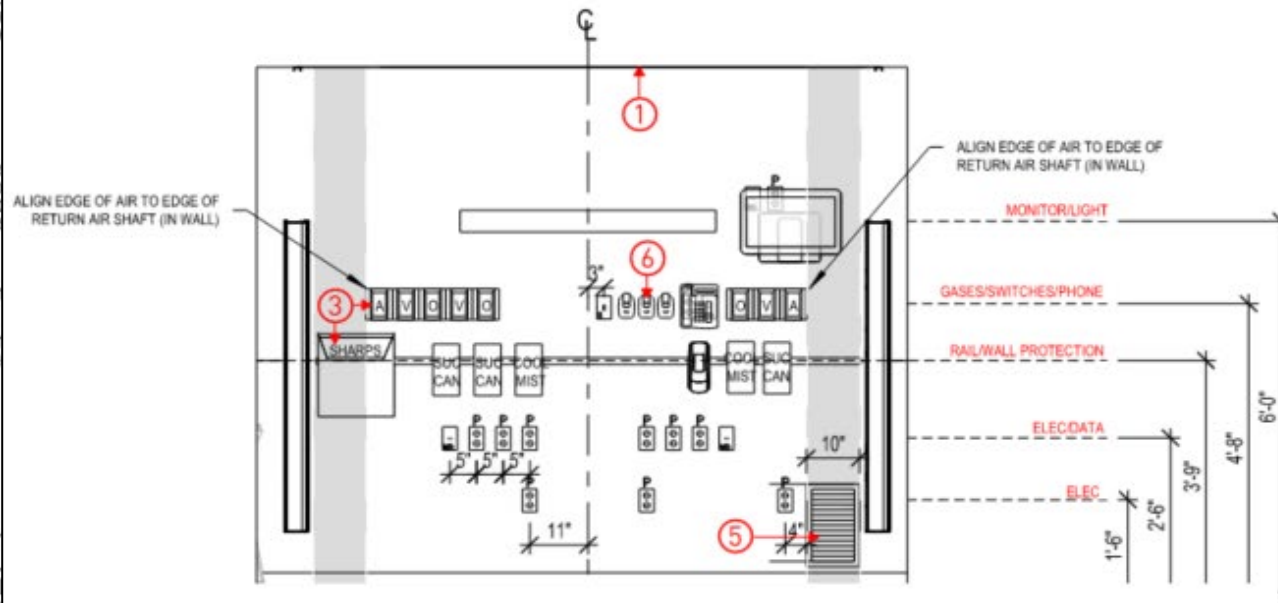
HALF HEIGHT
PROTECTION

PACU Headwall Mock Up Day 2

July 23, 2020



2. Team still deciding whether to mount sharps containers to side of nurse servers or gloves - TBD
3. Moved sharps container up and moved AVOVO to the right
4. Team would like to explore an alternative to the gooseneck light mounted to the rail. Would rather have a smaller light that mounts directly to the WOW. Ideally would charge via USB into computer vs. wall outlet.
5. Return air ducts will need to be adjusted so that they aren't behind nurse servers.
6. Rearranged light switches and call buttons - reference updated elevations on next page.
7. Need to accommodate 2 - 3 baskets on rail for tubing and cords.



OPEN BAY HEAD WALL

SCALE: 3/8" = 1'-0"

KEY DECISIONS

1. The ceiling-mounted light will be used for examination and will be turned on only for that purpose. Otherwise that light will remain off. Needs separate switch

Design Solutions



- PRIVATE BAY – scattered to clustered
- INDUCTION - eliminated
- TEAM DESK - centralized
- CLINICAL SUPPORT centralized
- STAFF SUPPORT – added in department
- ↔ FAMILY ENTRY– consolidated

Post-Occupancy Walkthrough

CURRENT ISSUE	HISTORY	ACTION TO TAKE	LESSONS LEARNED
Improve protocols for handling patients of size	New item of concern	FGI has protocols for this that were shared	- Stakeholders don't come to meetings prepared - Only department leadership participates - Think they know because they've done it before then end up having to table decisions during meetings
Headwall and bay design changes	Explored with mockup in design phase	New thinking/processes. Will need new mockup-referred to headwall vendor	
Second way out of neighborhoods in case of active shooter	- Design tradeoffs to centralize team workstation and clinical support. - Desire to minimize access points - Neighborhood strategy to break down the density	Active shooter scenarios not a consideration during design	
Acoustics	Intentions for how curtains would work were not implemented in construction	Consider changing curtain type or adding additional panels	



CRITICAL ACCESS HOSPITAL MOCKUPS

Testing/ prototyping

Hybrid simulation with physical mockups and augmented reality in a wide range of spaces.

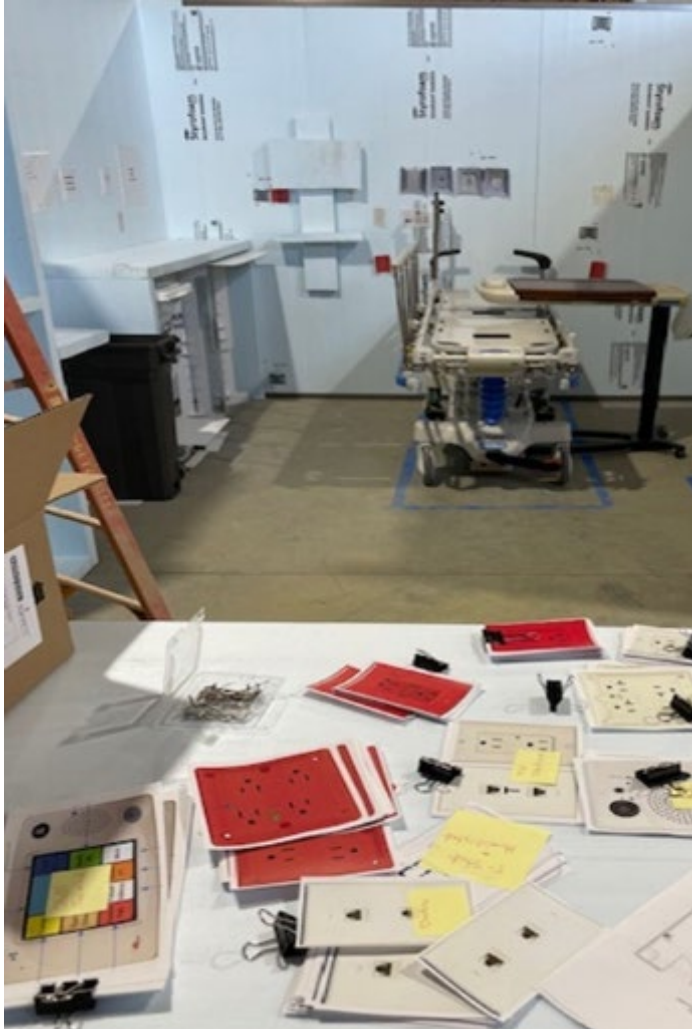
HF review focused on locations for equipment, furniture, and supplies to support tasks and links for different staff roles.

Architects used EBD in real time to refine the design and allow stakeholders to participate in the full process

- 2 rounds @ 2 days each of review at end of Design Development (DD) Workshops.
- 5 typical patient care rooms.
 - ED Exam
 - Pre/Post Op
 - OR (smallest)
 - Patient Room
 - Labor and Delivery Room (LDR)
- 1 local contractor's warehouse
- 5 final sign-offs of typical patient care rooms

High Fidelity Mock-Ups

Prep



Courtesy of GBBN Architects

Stakeholder Engagement





For Detailed Information



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Jiang, S., Mazzi, A., Miller, K., Wolf, L., Peng, Y., Sanghavi, H., ... & Webster, K. (2025). The Intersection of Human Factors and Evidence-Based Healthcare Design: A Conceptual Framework. *HERD: Health Environments Research & Design Journal*, 19375867251332618.



Additional Info: ROI Estimation



Simple Mock-Up

\$26.85

ROI per \$1 invested

HQCA (2020) Guideline

Detailed Mock-Up

\$16.66

ROI per \$1 invested

HQCA (2020) Guideline

Immersive VR Mock-Up

\$5-\$26

Savings between \$5 and \$26
in future renovation costs

NORR and Advanced
Performance (2024)

“Traditional design processes make best guesses at what is required in the clinical space. Using immersive design, we have found up to 18% cost savings on capital project costs.” (NORR and Advanced Performance, 2024, 9)

- The Center for Health Facilities Design and Testing, Clemson University
- <https://www.clemson.edu/centers-institutes/health-facilities-design-testing/resources/>
- Colman, N., Edmond, M. B., Dalpiaz, A., Walter, S., Miller, D. C., & Hebbar, K. (2020). Designing for patient safety and efficiency: simulation-based hospital design testing. HERD: Health Environments Research & Design Journal, 13(4), 68-80.



Acknowledgement

Human Factors Transforming Healthcare



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1. Cincinnati Children's Hospital Medical Center
2. Carilion Clinic
3. Corewell Health
4. Froedtert Health
5. Georgia Southern University
6. GBBN Architects